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SPACE SHUTTLE
TRACKING AND COMMUNICATION SUPPORT
DESIGN NOTE

STUDY OF ORBITER/PAYLOAD INTERFACE COMMUNICATIONS CONFIGURATION CONTROL BOARD DIRECTIVE FROM AN OPERATIONAL PERSPECTIVE

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(NASA-CR-147767) STUDY OF ORBITER/PAYLOAD INTERFACE COMMUNICATIONS CONFIGURATION CONTROL BOARD DIRECTIVE FROM AN OPERATIONAL PERSPECTIVE (MCDONNELL-DOUGLAS CORP.) 44 P HC $4.00 CSCL 17B G3/17

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1. Summary

The Configuration Control Board Directive (CCBD) entitled Orbiter/Payload Interface Communications (Attachment 1) greatly increases the capability of the Orbiter to communicate with a wide variety of projected Shuttle payloads. However, rather than being derived from individual payload communication requirements, the CCBD appears to be based on an operational philosophy that requires the Orbiter to duplicate or augment the Ground Network/Payload communication links. This philosophy is not substantiated by the Space Shuttle Program Requirements Document, Level I, Rev. No. 6 (Attachment 2). Orbiter capabilities with the implementation of the CCBD should be reviewed and compared with the Level I Program Requirements Document, any differences reconciled, and interface characteristics defined.

With or without the CCBD, many incompatibilities between Orbiter capabilities and projected payload characteristics appear to exist, as indicated by the entries accompanied by asterisks in Tables 2 and 3. Interfaces between Shuttle and payloads should be reviewed jointly by JSC and cognizant representatives of the "payload community" and any incompatibilities eliminated.

2. Introduction

In response to a Program Office request, a study of the Orbiter/Payload data and communications interface impact resulting from RECP R00686A has been performed from an operational perspective.

The study was initiated with the objective of providing an independent assessment of the necessity of the changes proposed in the RECP. The CCBD implementing portions of the RECP is contained in Attachment 1 and has been used as the basis for this study.

3. Orbiter/Payload Communication Baseline

Table 1 presents a summary of the Orbiter/Payload interface requirements delineated in the CCBD vs. the baseline requirements. A preliminary attempt at implementing the CCBD requirements into the affected Orbiter hardware design at the signal flow level has been performed by JSC and support personnel and is shown in Figures 1 and 2.

4. Payload Communication Requirements

A. Basis for Requirements in CCBD

In an attempt to identify which specific payloads generated the individual requirements reflected in Attachment 1, personnel at JSC, MSFC, GSFC, JPL, and Langley were contacted. It was not possible to assign specific requested changes to particular payloads or groups of payloads; rather, it was universally stated that the requirements given in Attachment 1 were generated from consultations among representatives of the payload community and that they reflect the minimum requirements governing payload design [i. e., they represent the Network (STDN, DSN, and SCF) Communication Standards and Tracking Data Relay Satellite System (TRRSS) User's Guide Requirements].

It was considered necessary that the Orbiter implement the same functional capabilities as the Ground Networks and the TDRSS so that

Orbiter-to-Payload communications could be accomplished in the same manner as Payload-to-Ground communications. Specific, detailed, documented payload requirements necessitating augmentation of the Ground/Payload link with a Ground/Orbiter/Payload or Orbiter/Payload Link were not available. Several generalized reasons for this capability such as crew safety, increased communication coverage, and payload checkout by the Orbiter were mentioned by representatives of the "payload community."

Space Shuttle Traffic Model TM X-64751 Rev. 2 (Reference 7) shows a total of 986 payloads, distributed as follows:

NASA AUTOMATED	221	
NASA SORTIE	286	
NASA TOTAL		507
NON-NASA AUTOMATED	125	
NON-NASA SORTIE	50	
NON-NASA TOTAL		175
DOD		304
SUM TOTAL		986

The sortie and DOD payloads account for a minor portion of the overall requirements represented by the CCBD. The automated (detached) payloads (total, 346) account for the greater part of the changes - particularly the ones with greatest overall Program cost impact [selectable modulation/RF configurations (part 1 of CCBD), many new command and bit rates (parts 2 and 4), and pre-launch payload direct RF link (part 6)]. All of this group except part 6 imply operational use of the Orbiter as an extension of the STDN and TDRS, rather than as a delivery/retrieval conveyance and limited in-orbit checkout support vehicle.

B. Payloads Command Telemetry Requirements

Tables 2 and 3 show payload requirements extracted from MSFC Level A Data documents Summarized Nasa Payload Descriptions (Preliminary) for Automated (Detached) and Sortie (Attached) Payloads (References 3 and 4, respectively). No comparable descriptions could be located for DOD payloads. Foreign Automated payloads are included in the Level A Automated Payload Data document, but foreign Sortie payloads are not in the companion Level A Sortie Payloads document; the latter are in a separate European Space Research Organization (ESRO) Space Shuttle Payload Description (SSPD) document which was not available for this study. However, the author of the Automated Payloads Level A document stated that the foreign Sortie Payload communication requirements are very similar to those given in the Sortie Payloads Level A Data document.

As shown by Tables 1 and 2, many bit rates required for payload commands and telemetry, according to the MSFC Level A Payload Data documents (reference 3 and 4), are not available in either the current baseline Orbiter T&C system or in the new baseline as it will exist with the implementation of Attachment 1. Also, in those cases where a wide-band communications link is implied, it is characterized as X-Band rather than the currently-planned Ku-Band.

5. Space Shuttle Program Requirements

The Space Shuttle Program Requirements Document, Rev. No. 6 (Attachment 2) was used to assess the operational requirements levied on the Orbiter by NASA OMSF. Pertinent sections or parts of sections are repoduced here for the convenience of the reader (underlining by author of this study).

3.0 OPERATIONAL REQUIREMENTS

3.1 General. The Space Shuttle System shall be designed to accomplish a wide variety of missions. The Shuttle System weight carrying capability into circular orbit shall be based on the performance required to execute mission 3A. The equivalent maximum performance is shown in figures 3.1 and 3.2 for the range of inclinations and altitudes indicated. The payload capability curves assume a simple deployment mission with no rendezvous, 22 fps (6.9 m/sec) OMS Reserves, 4,500 lbs. (2.041 kg) of RCS propellant, and direct deorbit. (Reentry performance restrictions are addressed in Par 2.4. Detailed Shuttle System performance questions should be addressed to the JSC Shuttle Program Office).

Space Shuttle missions will involve direct delivery of payloads to specified low Earth orbits; placement of payloads and transfer stages in parking orbits for subsequent transfer to other orbits; rendezvous and station keeping with detached payloads for on-orbit checkout;

return of payloads to Earth from a specified orbit; and provisions for routine and special support to space activities such as sortie missions, rescue, repair, maintenance, servicing, assembly, disassembly and docking.

4.0 ORBITER/PAYLOAD INTERFACE REQUIREMENTS

4.1 Payload Definition. Payloads referred to throughout this document are construed as the collective grouping of space hardware items such as: Spacelab, experiments, research equipment, satellites, support modules, adapters and fueled transfer stages or equipment, into appropriate composite flight packages. For definition of Shuttle/Orbiter payload accommodations, refer to Space Shuttle System Payload Accommodations Document. In the interest of maintaining minimum interface, (clean interface philosophy), payload designs should, where possible be self-sufficient systems, capable of checkout before installation in the Orbiter and adaptable to standardized interface concepts jointly developed between payloads and Space Shuttle.

4.2 Checkout. Payload performance testing and payload system checkout will be required prior to installation. Payload checkout while on the launch pad will be minimized and physical access to the payload will be limited. On-orbit status checks of the payload will be provided via the Orbiter prior to release and/or retrieval.

4.3 Data Management. The Orbiter shall provide standard displays and controls for monitoring the safety status of the payload. The payload shall provide to the Orbiter, at the interface, such information concerning the status or condition of the payload as is necessary to insure safe vehicle operation. Digital, discrete, and analog signals shall be conditioned by the payload and supplied to the Orbiter Vehicle. Such equipment and capability shall be chargeable to the payload. Payload unique control and display accommodation with the Orbiter cabin shall be chargeable to the payload. <u>A minimum standard interface shall be provided to exchange data for safety and payload status checks, and vehicle and operational parameters, such as navigation, guidance and control. Additional support may be feasible during certain operational modes.</u>

4.4 Payload Communication. <u>The Orbiter shall provide direct and relay telemetry, command, and two-way voice capability with attached payloads and with released payloads. The Orbiter shall be capable of receiving and displaying limited payload data including video information and the RF downlink shall provide for relay of these limited payload data to the ground for both attached payloads and for released payloads.</u>

6. Conclusions and Recommendations

No documented evidence could be found to indicate that the operational capabilities provided by the CCBD were derived directly from the requirements of individual payloads. Rather, it appears that they were drawn from ground network and TDRSS capabilities. The CCBD therefore appears to be based on an operational philosophy that implies operational use of the Orbiter as an extension of the STDN, SCF, and TDRSS, rather than as a delivery/retrieval conveyance and limited in-orbit checkout support vehicle. This premise is not substantiated by the Level I Space Shuttle Program Requirements Document, Rev. No. 6, which requires a minimum standard interface. The need for Orbiter-in-the-loop Ground/Payload communications should be investigated. Perhaps the Orbiter could perform limited payload checkout via hardline prior to payload deployment and control could be shifted to direct Ground/Payload RF link or relay via TDRS. Generalized payload requirements cited to justify the CCBD relative to crew safety, unbroken communications during deployment, and communications contact time should be substantiated and documented on an individual payload basis.

If it is considered mandatory to implement the CCBD, alternative methods of achieving the RF and modulation capabilities should be investigated - for example, mission-specific configuration employing "plug-in" modules for different RF channels and modulation schemes. This might significantly reduce initial Program costs

associated with Orbiter/Payload interface requirements, and facilitate the incorporation of advances in technology during the life of the Program.

Many apparent incompatibilities remain to be eliminated. For example, many command and telemetry bit rates reflected in Reference 3 and 4 (summarized in Tables 2 and 3) are not included in the current baseline, nor are they accounted for in the CCBD. Also, there are several references to X-Band RF for automated payloads.

The interface should be reviewed jointly by JSC and cognizant representatives of the "payload community" and any incompatibilities eliminated to avoid possible "surprises" later.

TABLE 1
ORBITER
SELECTABLE FREQUENCIES
FOR PAYLOAD INTERFACE

CURRENT BASELINE CAPABILITIES	NEW CCBD CAPABILITIES
NASA	NASA
Tx: 2028.135 to 2115.614 MHz (20 CH) 4.604 MHz INCREMENTS Rx: 2202.5 to 2297.5 MHz (20 CH) 5.0 MHz INCREMENTS	P/L WITH STDN Tx: 2025 to 2110 MHz (739 CH) 115.1 KHz INCREMENTS Rx: 2200 to 2290 MHz (721 CH) 125 KHz INCREMENTS P/L WITH TDRSS MULTIPLE ACCESS Tx: 2092.59375 or 2106.40625 MHz Rx: 2272.5 or 2287.5 MHz P/L WITH DEEP SPACE NETWORK TX: 2110.243056 to 2119.792430 MHz (29 CH) 341,049 Hz INCREMENTS RX: 2290.185185 to 2299.814815 MHZ (27 CH) 370,370 Hz INCREMENTS P/L WITH ORBITER/TDRSS TX: 2028.1354 to 2115.6145 MHz (20 CH) * 4.6041 MHz INCREMENTS RX: SAME
DOD	DOD P/L WITH AIR FORCE SGLS
TX: 1763.721 to 1839.795 MHz (20 CH) 4.004 MHz INCREMENTS	TX: SAME
RX: 2202.5 to 2297.5 MHz (20 CH) 4.0 MHz INCREMENTS	RX: SAME

* ESSENTIALLY THE SAME AS CURRENT BASELINE.

TABLE 1 (Continued)
ORBITER
SELECTABLE MODULATION
FOR PAYLOAD INTERFACE

CURRENT BASELINE CAPABILITIES	NEW CCBD CAPABILITIES
NASA	**NASA**
	P/L WITH STDN
Tx: PCM (Bi-Ø-L)/PM	Tx: PCM/PSK /PM S/C: 30 KHz and/or 70 KHz
Rx: PCM (Bi-Ø-L)/PM	Rx: PCM/PM/PM S/C: 48, 64, 128, 192, 256, 384 576, 768, 1024, 1600 KHz
	P/L WITH TDRSS MULTIPLE ACCESS
	Tx & Rx: PCM/PRN/PSK SPREAD SPECTRUM
	P/L WITH DEEP SPACE NETWORK
	Tx: PCM/PSK/PM S/C: ANY EXISTING DSN UPLINK S/C
	Rx: PCM/PSK/PM S/C: ANY EXISTING DSN DOWNLINK S/C
	P/L WITH ORBITER/TDRSS
	Tx: TDM/PSK 8 KBPS COMMAND OR 8 KBPS COMMAND PLUS 32 KBPS Δ-MOD VOICE
	Rx: TDM/PSK 16 KBPS DATA OR 16 KBPS DATA PLUS 32 KBPS Δ-MOD VOICE
DOD	**DOD**
	P/L WITH AIR FORCE SGLS
Tx: FSK/AM Tones (65, 76, 95 KHz)/PM	Tx: ON-OFF KEYED, AM TONES (65, 76, 95KHz)/PM
Rx: PCM/PSK/PM (PSK DATA ON 1.024 MHz subcarrier)	Rx: PCM/PSK/FM (Data on 1.024 MHz S/C) and PCM/PSK/FM or (IRIG-FM/FM)/FM (Data on 1.7 MHz S/C)

TABLE 1 (Continued)

ORBITER/
PAYLOAD COMMAND BIT RATES

CURRENT BASELINE CAPABILITIES	ADDED CCBD CAPABILITIES
NASA: 2 KBPS	NASA: DETACHED & ATTACHED 1,2,4,8,16,32,64,128 256,512 and 1000 BPS (3.84 KBPS ATTACHED ONLY)
DOD: 2 K-BAUD	DOD: 1 K-BAUD

ORBITER/
PAYLOAD TELEMETRY BIT RATES
FOR PAYLOAD INTERFACE

CURRENT BASELINE CAPABILITIES	ADDED CCBD CAPABILITIES
NASA: 16 KBPS	NASA: 8 THROUGH 128 BPS INCLUSIVE IN 1-BPS INCREMENTS; AND 1,2,4 and 8 KBPS NOTE: (JPL INDICATES THAT THE 1-BPS INCREMENT WILL BE CHANGED TO 2-BPS INCREMENTS)
DOD: 16 KBPS	DOD: 250 BPS, 500 BPS, and 1,2,4 8 AND 10 KBPS

ORBITER/
PAYLOAD COMMAND HARDLINE INTERFACE

CURRENT BASELINE CAPABILITIES	ADDED CCBD CAPABILITIES
NASA: BI-Ø-L DATA LINE	NASA: NRZ-L DATA LINE, CLOCK LINE, AND P/L ENABLE LINE
DOD: FSK/AM TERNARY SIGNAL AT A 2 K BAUD RATE	DOD: 3 DATA LINES (1, 0, S) AND CLOCK LINE

TABLE 1 (Continued)

ORBITER/
PAYLOAD TELEMETRY HARDLINE INTERFACE

CURRENT BASELINE CAPABILITIES	ADDED CCBD CAPABILITIES
NASA: Bi-Ø-L DOD: NRZ-L PLUS CLOCK (CLEAR OR SECURE)	NASA: NRZ-L PLUS CLOCK DOD: SAME NOTE: DELETE THE REQMT FOR ORBITER TO RECEIVE MAJOR AND MINOR FRAME SYNC INPUTS.

ORBITER/
PAYLOAD DIRECT RF LINK - PRELAUNCH

CURRENT BASELINE CAPABILITIES	ADDED CCBD CAPABILITIES
NONE	1) DIRECT RF COMM (TX & RX BETWEEN P/L's IN THE ORBITER P/L BAY (DOORS OPEN OR CLOSED) & P/L's GSE DURING PRELAUNCH. 2) RF RADIATION INSIDE THE BAY WILL NOT BE DETRIMENTAL TO OTHER SYSTEMS, SUBSYSTEMS, OR P/L's 3) S-BAND LINK VIA THE P/L's ANT. NOTE: THE LINK SHALL NOT REQUIRE AN ACTIVE ORBITER COMM SYSTEM

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TABLE 2 - AUTOMATED PAYLOADS

PAYLOAD	AGENCY	MISSION	SCHEDULE													UPLINK RATE (MAX)b/S	DOWNLINK TM TO SHUTTLE (MAX)b/S	FREQ BAND
			79	80	81	82	83	84	85	86	87	88	89	90	91			
		ASTRONOMY																
AS-01	MSFC	Large Space Telescope		1	1	1	2	1	1	1	1	2	1	1	1	1024*	51.2K*	S
AS-02	MSFC	Large Space Telescope		1		1		1		1		1		1		256	430K*	S
AS-03	NASA	Cosmic Background Explorer	1		1		1		1		1		1		1	256	40,960*	S
AS-05	NASA	Advanced Radio Explorer		1			1		1		1					128	2048*	S
AS-07	NASA	3M Ambient Temperature IR Telescope					1	1	1	2	1	1	2	1	1	1024*	23K*	S
AS-11	NASA	1.5m IR Telescope			2	4	4	3	4	4	3	4	4	3	4	2048*	22,764*	S
AS-13	NASA	UV Survey Telescope		2	2			2	2	2					2	1707*	2124*	S
AS-14	NASA	1.0m UV-Optical Telescope			1	1	1	2	1	1	2	1	1	2	1	2048*	3072*	S
AS-16	NASA/OSS	Large Radio Observatory Array (LROA)							1		1		1		1	2048*	102.4K*	S
AS-17	NASA	30m IR Interferometer							1	1	2	1	1			3072*	100K*	S
		HIGH ENERGY ASTROPHYSICS																
HE-01	NASA	Large X-Ray Telescope Facility								1		1		1	1	2048*	35K*	S
HE-03	NASA	Extended X-Ray Survey				1	1		1	1						2048*	64,816*	S
HE-05	NASA/OSS	High Latitude Cosmic Ray Survey													1	2048*	26K*	S
HE-07	NASA	Small High Energy Satellite			1			1				1				256	40,960*	S
HE-08	NASA	Large High Energy Observatory A (Gamma Ray)								1	1		1	1		2048*	12,048*	S
HE-09	NASA	Large High Energy Observatory B (Magnetic Spectrometer)		1												2048*	12,048*	S
HE-10	NASA/OSS	Large High Energy Observatory C (Nuclear Calorimeter)									1		1		1	2048*	8K	S
HE-11	NASA	Large High Energy Observatory D (1.2m X-Ray Telescope)					1	1	1		1					2048*	35K*	S
HE-12	NASA	Cosmic Ray Laboratory									1	1	1	1	1	2048*	35K*	S
		SOLAR PHYSICS																
SO-02	GSFC/MSFC	Large Solar Observatory							1	1	1	1	1	1		TBD	NA	S
SO-03	NASA	Solar Maximum Mission		2		2		2		2		2		2		1200*	6400*	S
		* Bit rate or RF incompatibility																

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TABLE 2 - AUTOMATED PAYLOADS (CONTINUED)

PAYLOAD	AGENCY	MISSION	SCHEDULE													UPLINK RATE (MAX)b/S	DOWNLINK TM TO SHUTTLE (MAX)b/S	FREQ BAND
			79	80	81	82	83	84	85	86	87	88	89	90	91			
		ATMOSPHERIC AND SPACE PHYSICS																
AP-01	NASA/OSS	Upper Atmosphere Explorer	1		1				1				1			TBD	NA	S
AP-02	NASA/OSS	Medium Altitude Explorer	1				1				1				1	TBD	NA	S
AP-03	NASA	High Altitude Explorer		1		1		1		1		1		1		TBD	NA	S
AP-04	NASA	Gravity and Relativity Satellite - LEO		1			1									TBD	NA	S
AP-05	NASA	Environmental Perturbation Satellite - Mission A			1			1								NA	NA	-
AP-06	NASA/OSS	Gravity and Relativity Satellite Solar								1					1	NA	NA	-
AP-07	NASA/OSS	Environmental Perturbation Satellite - Mission B									1			1		NA	NA	-
AP-08	NASA/OSS	Heliocentric and Interstellar Spacecraft										1				NA	NA	-
		EARTH OBSERVATIONS																
EO-07	NASA/NOAA	Advanced Synchronous Meteorological Satellite									1					NA	1200*	S
EO-08	NASA	Earth Observatory Satellite	1	1	1	3	2	2	2	3	2	2	2	2	2	NA	NA	-
EO-09	NASA	Synchronous Earth Observatory Satellite			1		1		1		1		1		1	NA	1362*	S
EO-10	NASA	Applications Explorer (Special Purpose Satellite)	2	2	2	1	1	1	1	1	1	1	1	1	1	NA	800*	S
EO-12	NASA	TIROS 'O'				1		1			1		1			NA	10K	S
EO-56	NASA	Environmental Monitoring Satellite		1	1	1			1	1	1	1		1	1	NA	10K	S
EO-57	FOREIGH	Foreign Synchronous Meteorological Satellite			1	1		1		1		1		1		NA	1070*	S
EO-58	NOAA	Geosynchronous Operational Meteorological Satellite	1		1	1	1		1		1	1	1		1	NA	1070*	S
EO-59	NASA	Geosynchronous Earth Resources Satellite										2		2		NA	1362*	S
EO-61	NASA	Earth Resources Survey Operational Satellite	1	1	1	1	1	1	1	1	1	1	1	1	1	NA	10K	S
EO-62	FOREIGN	Foreign Synchronous Earth Observatory Satellite										1	2		1	NA	1362*	S

* Bit rate or RF incompatibility

TABLE 2 - AUTOMATED PAYLOADS (CONTINUED)

PAYLOAD	AGENCY	MISSION	SCHEDULE													UPLINK RATE (MAX)b/S	DOWNLINK TM TO SHUTTLE (MAX)b/S	FREQ BAND
			79	80	81	82	83	84	85	86	87	88	89	90	91			
		EARTH AND OCEAN PHYSICS																
OP-01	NASA	GEOPAUSE	1			1										NA	NA	-
OP-02	NASA	Gravity Gadiometer		1												NA	NA	-
OP-03	NASA	Mini-LAGEOS		3					3							NA	NA	-
OP-04	NASA	GRAVSAT	1													NA	NA	-
OP-05	NASA	Vector Magnetometer Satellite			3					3				3		NA	564*	S
OP-06	NASA	Magnetic Field Monitor Satellite			1					1						NA	564*	S
OP-07	NASA	SEASAT B				1										NA	1.5 M*	S
OP-51	NOAA	Global Earth & Ocean Monitor System								3		3		3		TBD	TBD	TBD
		SPACE PROCESSING APPLICATIONS																
SP-01	MSFC	Space Processing Free-Flyer							TBD							NA	NA	-
		LIFE SCIENCES																
LS-02	OMSF/ARC	Biomedical Experiment Scientific Satellite		3	4	4	4	4	4	4	4	4	4	4	4	TBD	NA	S
		SPACE TECHNOLOGY																
ST-01	LARC/OAST	Long Duration Exposure Facility		2		2		2		2		2		2		NA	NA	-
		* Bit rate or RF incompatibility																

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TABLE 2 - AUTOMATED PAYLOADS (CONTINUED)

PAYLOAD	AGENCY	MISSION	SCHEDULE													UPLINK RATE (MAX)b/S	DOWNLINK TM TO SHUTTLE (MAX)b/S	FREQ BAND
			79	80	81	82	83	84	85	86	87	88	89	90	91			
		PLANETARY																
PL-01	NASA	Mars Surface Sample Return						2								16	NA	S&X*
PL-02	NASA	Mars Satellite Sample Return												1	1	16	TBD	S&X*
PL-03	NASA	Pioneer Venus Multiprobe		1	2		1			1						TBD	NA	S&X*
PL-07	NASA/JPL	Venus Orbital Imaging Radar					2									16	TBD	S&X*
PL-08	NASA	Venus Buoyancy Probe							2							16	TBD	S&X*
PL-09	NASA	Mercury Orbiter									2					16	TBD	S&X*
PL-10	NASA	Venus Large Lander											2			16	NA	S&X*
PL-11	NASA	Pioneer Saturn/Uranus Flyby			1											TBD	NA	S&X*
PL-12	NASA	Mariner Jupiter Orbiter			2											16	NA	S&X*
PL-13	NASA	Pioneer Jupiter Probe						2								TBD	NA	S&X*
PL-14	NASA	Saturn Orbiter							2							16	TBD	S&X*
PL-15	NASA	Uranus Probe/Neptune Flyby								2						16	TBD	S&X*
PL-16	NASA	Ganymede Orbiter/Lander												1	1	16	TBD	S&X*
PL-18	NASA	Encke Rendezvous			2											80*	16	S&X*
PL-19	NASA	Halley Comet Flyby							1							16	TBD	S&X*
PL-20	NASA	Asteroid Rendezvous								2						16	TBD	S&X*
PL-22	NASA	Pioneer Saturn Probe		1												TBD	NA	S&X*
		COMMUNICATIONS/NAVIGATION																
CN-51	COMSAT	INTELSAT	2	3			2	3	2	2			2	3	2	NA	1024*	S
CN-52	NASA/FCC	US DOMSAT A	1	1	2	2	1									NA	NA	-
CN-53	FCC	US DOMSAT B						1	1	2	2	3	2	2	1	NA	NA	-
CN-54	LEWIS/NOAA	DISASTER WARNING Satellite			1	1			1							NA	600*	S
CN-55	MARAD/FAA	Traffic Management Satellite	1	2	2	1	1	1		1		1		1		NA	512*	S
CN-56	FOREIGN	Foreign Communications Satellite A			1	1	1	1								NA	1000	S
CN-58	NASA	Domestic Communications Satellite C					3					3				NA	NA	-
CN-59		Communications R&D/Prototype Satellite							1			1		1		NA	NA	-
CN-60	FOREIGN	Foreign Communications Satellite B							1	1	1	1	1	1	1	NA	NA	-

* Bit rate or RF incompatibility

TABLE 2 - AUTOMATED PAYLOADS (CONTINUED)

PAYLOAD	AGENCY	MISSION	SCHEDULE													UPLINK RATE (MAX)b/S	DOWNLINK TM TO SHUTTLE (MAX)b/S	FREQ BAND
			79	80	81	82	83	84	85	86	87	88	89	90	91			
		LUNAR																
LU-01	NASA/OSS	Lunar Orbiter						1		1						16	NA	S
LU-02	NASA/OSS	Lunar Rover									1	1				NA	NA	-
LU-03	NASA/ODTA	Lunar Halo Satellite											1			NA	NA	-
LU-04	NASA/OSS	Lunar Sample Return												1	1	NA	NA	-

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TABLE 3

SORTIE PAYLOADS

PAYLOAD	AGENCY	MISSION	SCHEDULE													DIGITAL RATE (MAX) b/S	
			79	80	81	82	83	84	85	86	87	88	89	90	91	R/T DOWNLINK	UPLINK
		ASTRONOMY															
AS-01-S	NASA	1.5m Cryogenically-Cooled IR Telescope		1	2	2	2	2	1		1	1	1	1	1	21740	1024*
AS-03-S	NASA	Deep Sky UV Survey Telescope		1	1			1	2	1		1			1	2132	2048*
AS-04-S	NASA	1m Diffraction Limited UV Optical Telescope						1	2	3	3	4	3	3	4	2000	1024*
AS-05-S	NASA	Very Wide Field Galactic Camera				1	1									2500	128
AS-06-S	NASA/GSFC	Calibration of Astronomical Fluxes							1	1						$4X10^4$	2048*
AS-07-S	NASA/MSFC	Cometary Simulation							1	1						$3.1X10^6$ ††	0
AS-08-S	NASA/GSFC	Multipurpose 0.5m Telescope	12	12	12	12	12	12	12	12	12	12	12	12	12	$2X10^5$ †	1024*
AS-09-S	NASA OSS	30m IR Interferometer							1							$1X10^5$ †	2048*
AS-10-S	NASA/U of Cal Berkley	Adv. XUV Telescope								1	1	1	1	1	1	$5X10^5$ †	1024*
AS-11-S	NASA/GSFC	Polarimetric Experiments								1						$1X10^6$ †	20*
AS-12-S	NASA	Meteoroid Simulation							1	1						$3X10^6$ ††	0
AS-13-S	NASA	Solar Variation Photometer	24	24	24	24	24	24	24	24	24	24	24	24	24	N/A	128
AS-14-S	NASA	1.0m Uncooled IR Telescope		1	1	1	1									$2.2X10^4$	1024*
AS-15-S	NASA	3.0m Ambient Temperature IR Telescope					2	2	1	1	1	1	1	1	1	21740	1024*
AS-18-S	NASA	1.5 km IR Interferometer						1		1		1		1		$1X10^5$ †	2048*
AS-19-S	NASA	Selected Area Deep Sky Survey Telescope			2	2	2	2	2	2	2	2				$1X10^5$ †	1024*
AS-20-S	NASA	2.5m Cryogenically cooled IR Telescope											1	1	1	21740	1024*
AS-31-S	NASA/GSFC	Combined AS-01, -03, -04, -05-S		1	1	1	1	1	2	2	2	2	2	2	2	31752	4224*
AS-41-S	NASA	Schwartzschild Camera	2	2												$1X10^6$ †	512
AS-42-S	NASA	FAR UV Electronographic Schmidt Camera/Spectrograph	2	2	2											N/A	256
AS-43-S	U of Cal Berkley	UCB Black Brant Payload		1	1	1	1	1								$5X10^5$ †	0
AS-44-S	NASA	XUV Concentrator/Detector	1	1	1											11264	256
AS-45-S	NASA	Proportional Counter Array		1	1	1	1	1								$2X10^5$ †	128
AS-46-S	U of Wisconsin	Wisconsin UV Photometry Experiment	2	2	2	2										10000	1024*
AS-47-S	NASA/ARC	Attached Far IR Spectrometer (78)1	1	1												20000	128
AS-48-S	NASA/GSFC	Aries/Shuttle UV Telescope	3	3	3	3	3									$1X10^6$ †	256
AS-49-S	U of Cal Berkley	First UCB Black Brant Payload	1													500000†	0
AS-50-S	NASA	Combined UV/XUV Measurements (AS-04-S, 10-S)								1		1		1		$5.02X10^5$ †	2048*
AS-51-S	NASA	Combined IR Payload (AS-01-S, 15-S)					2	2								43480	2048*
AS-54-S	NASA	Combined UV Payload (AS-03-S, 04-S)						1	1	1		1			1	5300	3012*
AS-61-S	NASA/ARC	Attached Far IR Photometer (Wide FOV)	1	1												N/A	N/A
AS-62-S	UCB	Cosmic Background Anisotropy		1	1											1024	128
AS-01-R	NASA/MSFC	LST Revisit			1	1		1	1	1	1		1	1	1	51200	1024*

* BIT RATE INCOMPATIBILITY
† VIA S-BAND FM OR KU-BAND ONLY
†† VIA KU-BAND ONLY

TABLE 3 Cont.

SORTIE PAYLOADS

PAYLOAD	AGENCY	MISSION	SCHEDULE 79	80	81	82	83	84	85	86	87	88	89	90	91	DIGITAL RATE (MAX)b/S R/T DOWNLINK	UPLINK
		HIGH ENERGY ASTROPHYSICS															
HE-11-S	NASA/OSS	X-ray Angular Structure		1		1		1		1		1		1		43008	1024*
HE-12-S	NASA	High Inclination Cosmic Ray Survey			1		1	1	1				1			$1.7X10^4$†	1024*
HE-13-S	NASA/OSS	X-ray/Gamma Ray Pallet				1		1		1		1		1		32000	1024*
HE-14-S	NASA/OSS	Gamma Ray Pallet				1		1		1	1		1		1	11000	1024*
HE-15-S	NASA	Magnetic Spectrometer		1			1					1				12048	2048*
HE-16-S	NASA/GSFC	High Energy Gamma-Ray Survey			1		1				1					$2X10^5$†	1024*
HE-17-S	NASA	High Energy Cosmic Ray Study							1		1		1	1		$8X10^3$	1024*
HE-18-S	NASA	Gamma-ray Photometric Studies					1		1		1		1		1	31200	512
HE-19-S	NASA	Low Energy X-ray Telescope							1	1		1		1	1	12288	1024*
HE-20-S	NASA	High Resolution X-ray Telescope				1		1								$2X10^5$†	1024*
HE-03-R	NASA/MSFC	Extended X-ray Survey Revisit					1		1							64816	1024*
HE-11-R	NASA/MSFC	Large High Energy Observatory D Revisit						1	1				1	1	1	$2X10^5$†	2048*
		SOLAR PHYSICS															
SO-01-S	NASA	Dedicated Solar Sortie Mission (DSSM)		1	1	1	2	2	3	2	3	2	3	2	3	$1.32X10^7$††	TBD
SO-11-S	NASA	Solar Fine Pointing Payload		1	1	1	1	1								$1.32X10^7$††	3800*
SO-12-S	MSFC	ATM Spacelab TBD														72000†	1000
		ATMOSPHERIC AND SPACE PHYSICS															
AP-06-S	NASA/OSS	Atmospheric, Magnetospheric, and Plasmas (AMPS)			1	1	1	3	3	4	3	4	3	4	3	25000	$4X10^5$ *
		EARTH OBSERVATIONS															
EO-01-S	NASA	Zero-G Cloud Physics Laboratory		1	1	2	2	2	1	1	1					0	0
EO-05-S	NASA	Shuttle Imaging Microwave System (SIMS)		2	2	1	1	1	1	1	1	2	2	2	2	0	0
EO-06-S	NASA	Scanning Spectroradiometer		1	1	1	1	1	2	2	1	2	2	2	1	0	0
EO-07-S	NASA	Active Optical Scatterometer		1	1	1	1	1	1	1	2	2	2	2	1	0	2000

* BIT RATE INCOMPATIBILITY
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†† VIA KU-BAND ONLY

TABLE 3 Cont.

SORTIE PAYLOADS

PAYLOAD	AGENCY	MISSION	SCHEDULE													DIGITAL RATE (MAX)b/S	
			79	80	81	82	83	84	85	86	87	88	89	90	91	R/T DOWNLINK	UPLINK
		EARTH & OCEAN PHYSICS															
OP-02-S	NASA	Multifrequency Radar Land Imagery		2	2	2	2	1	1	1	2	2	2	1	1	2.66×10^5 †	TBD
OP-03-S	NASA	Multifrequency Dual Polarized Microwave Radiometry		1		1		1	1	1	1		1	1	1	0	2000
OP-04-S	NASA	Microwave Scatterometer			1		1	1	1	1		1		1	1	0	0
OP-05-S	NASA	Multispectral Scanning Imagery		2	2	2	2	1	1	1	2	2	2	1	1	2.66×10^5 †	TBD
OP-06-S	NASA	Combined Laser Experiment		1	1	1	1	2	2	2	1	1	1	2	2	3.42×10^4	TBD
		SPACE PROCESSING APPLICATIONS															
SP-01-S	NASA/MSFC	SPA No. 1 - Biological (Manned) (B+C)		1	1	1										22	0
SP-02-S	NASA/MSFC	SPA No. 2 - Furnace (Manned) (F+C)			1	1										2500	0
SP-03-S	NASA/MSFC	SPA No. 3 - Levitation (Manned) (L+C)			1	1										14000	0
SP-04-S	NASA/MSFC	SPA No. 4 - General Purpose (Manned) (G+C)		1	1	1	1	1	1	1	1	1	1	1	1	300	0
SP-05-S	NASA/MSFC	SPA No. 5 - Dedicated (Manned) (B+F+L+G+C)					1	1	1	1	1	1	1	1	1	14300	0
SP-12-S	NASA/MSFC	SPA No. 12 - Automated Furnace (FP+CP)		1	1	1										2500	0
SP-13-S	NASA/MSFC	SPA No. 13 - Automated Levitation (LP+CP)		1	1											14000	0
SP-14-S	NASA/MSFC	SPA No. 14 - Manned and Automated (B+G+C+FP+LP)				1	1	1	1	1	1	1	1	1	1	14300	0
SP-15-S	NASA/MSFC	SPA No. 15 - Automated Furnace/Levitation (FP+LP+CP)				1	1	1	1	1	1	1	1	1	1	14000	0
SP-16-S	NASA/MSFC	SPA No. 16 - Biological/General (Manned) (B+G+C)			1	1	1	1	1	1	1	1	1	1	1	300	0
SP-19-S	NASA/MSFC	SPA No. 19 - Biological and Automated (B+C+FP+LP)					1	1	1	1	1	1	1	1	1	14000	0
SP-21-S	NASA/MSFC	SPA No. 21 - Minimum Biological (B+C) TBD														20	0
SP-22-S	NASA/MSFC	SPA No. 22 - Minimum Furnace (Manned) (F+C) TBD														2000	0
SP-23-S	NASA/MSFC	SPA No. 23 - Minimum General (G+C) TBD														100	0
SP-24-S	NASA/MSFC	SPA No. 24 - Minimum Levitation (Manned) (L+C) TBD														12000	0
		LIFE SCIENCES															
LS-04-S	NASA/OMSF (MSFC)	Free Flying Teleoperator			1	2	1	1	1	1	1	1	1	1	1	3840	0
LS-09-S	NASA/OMSF	Life Sciences Shuttle Laboratory		2	2	2	2	2	2	2	2	3	3	3	3	14×10^3	0
LS-10-S	NASA/OMSF (MSFC)	Life Scineces Carry-on Laboratories		2	2	2	2	2	2	2	2	2	2	2	2	TBD	N/A

* BIT RATE INCOMPATIBILITY
† VIA S-BAND FM OR KU-BAND ONLY
†† VIA KU-BAND ONLY

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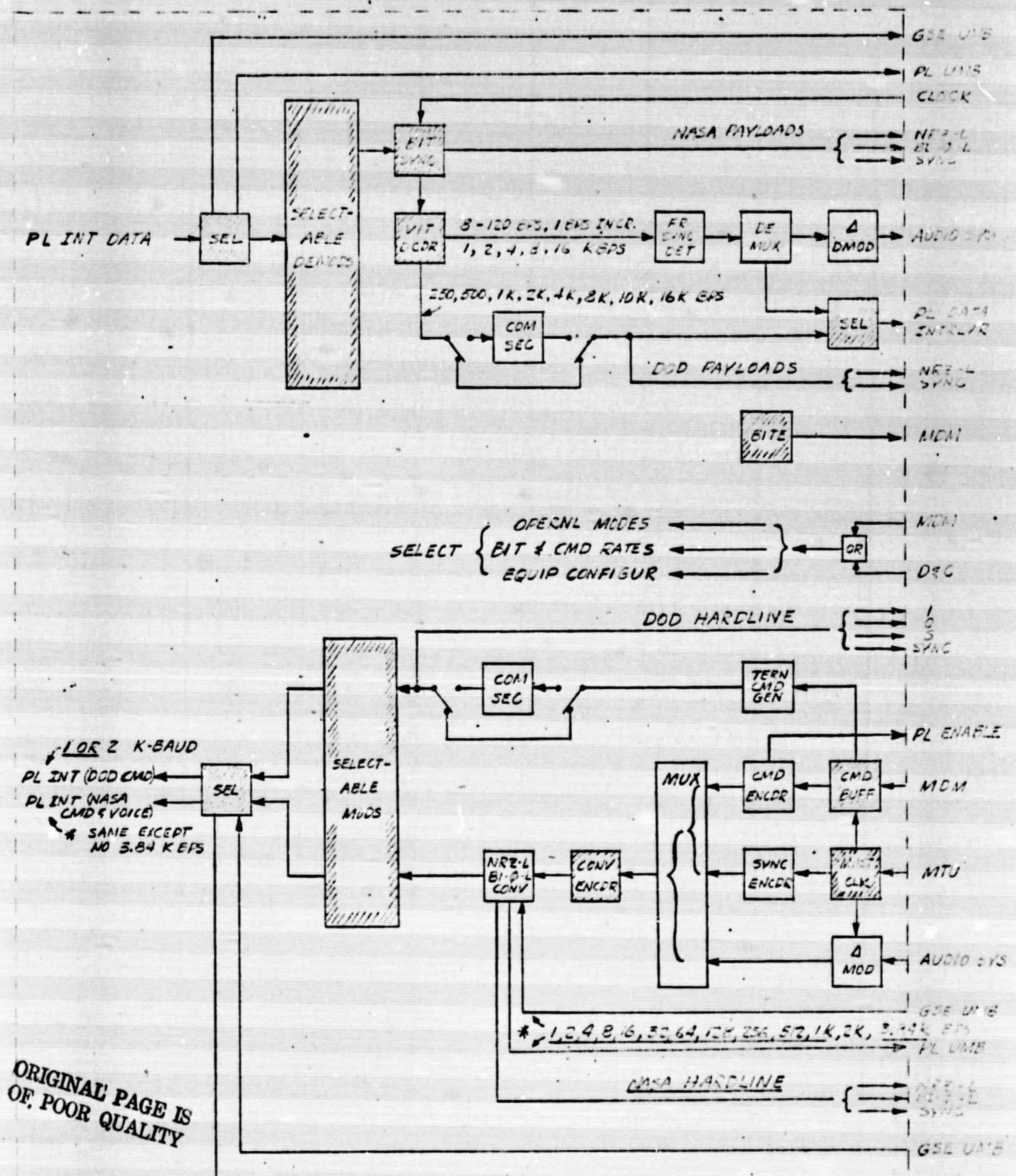
TABLE 3 Cont.

SORTIE PAYLOADS

PAYLOAD	AGENCY	MISSION	SCHEDULE													DIGITAL RATE (MAX)b/S	
			79	80	81	82	83	84	85	86	87	88	89	90	91	R/T DOWNLINK	UPLINK
		SPACE TECHNOLOGY															
ST-04-S	NASA/MSFC	Wall-less Chemistry + Molecular Beam (Facil. No. 1)		1	2	2	2	2	2	2	2	2	2	2	2	N/A	N/A
ST-05-S	NASA/MSFC	Superfluid He + Particle/Drop Positioning (Facil. No. 2)		1	2	2	2	2	2	2	2	2	2	2	2	N/A	N/A
ST-06-S	NASA/MSFC	Fluid Physics + Heat Transfer (Facil. No. 3)			1	2	2	2	2	2	2	2	2	2	2	N/A	N/A
ST-07-S	NASA/MSFC	Neutral Beam Physics (Facil. No. 4)			1	2	2	2	1	1						N/A	N/A
ST-08-S	NASA/MSFC	Integrated Real Time Contamination Monitor Flies on all Contamination Sensitive P/L Missions														N/A	N/A
ST-09-S	NASA/MSFC	Controlled Contamination Release		1	2											N/A	N/A
ST-11-S	NASA/MSFC	Laser Information/Data Transmission		2	1											N/A	N/A
ST-12-S	NASA	Entry Technology	2	4	4	2										N/A	N/A
ST-13-S	NASA	Wake Shield Investigation							2	2						N/A	N/A
ST-21-S	Langley Res. Ctn	ATL P/L No. 2 (Module + Pallet)				1	1		1	1		1	1		1	N/A	N/A
ST-22-S	Langley Res. Ctn	ATL P/L No. 3 (Module + Pallet)			1		1	1		1	1		1	1		N/A	N/A
ST-23-S	Langley Res. Ctn	ATL P/L No. 5 (Pallet Only)		1	1	1		1	1		1	1		1	1	N/A	N/A
		COMMUNICATIONS AND NAVIGATION															
CN-04-S	NASA	Terrestrial Sources of Noise + Interference			1	1	1	1				1	1	1	1	0	72*
CN-05-S	NASA	Laser Communication Experimentation				1	1	1			1	1	1			0	224 *
CN-06-S	NASA	Communication Relay Tests						1	1	1				1	1	0	0
CN-07-S	NASA	Large Reflector Deployment							1	1	1				1	0	0
CN-08-S	NASA	Open Traveling Wave Tube							1	1	1					0	0
CN-11-S	NASA	Stars & Pads Experimentation TBD														N/A	N/A
CN-12-S	NASA	Interferometric Navigation & Surveillance Techniques			1	1	1					1	1	1		0	0
CN-13-S	NASA	Shuttle Navigation Via Geosynchronous Satellite			1	1	1					1	1	1		0	TBD

*BIT RATE INCOMPATIBILITY

FIGURE 1



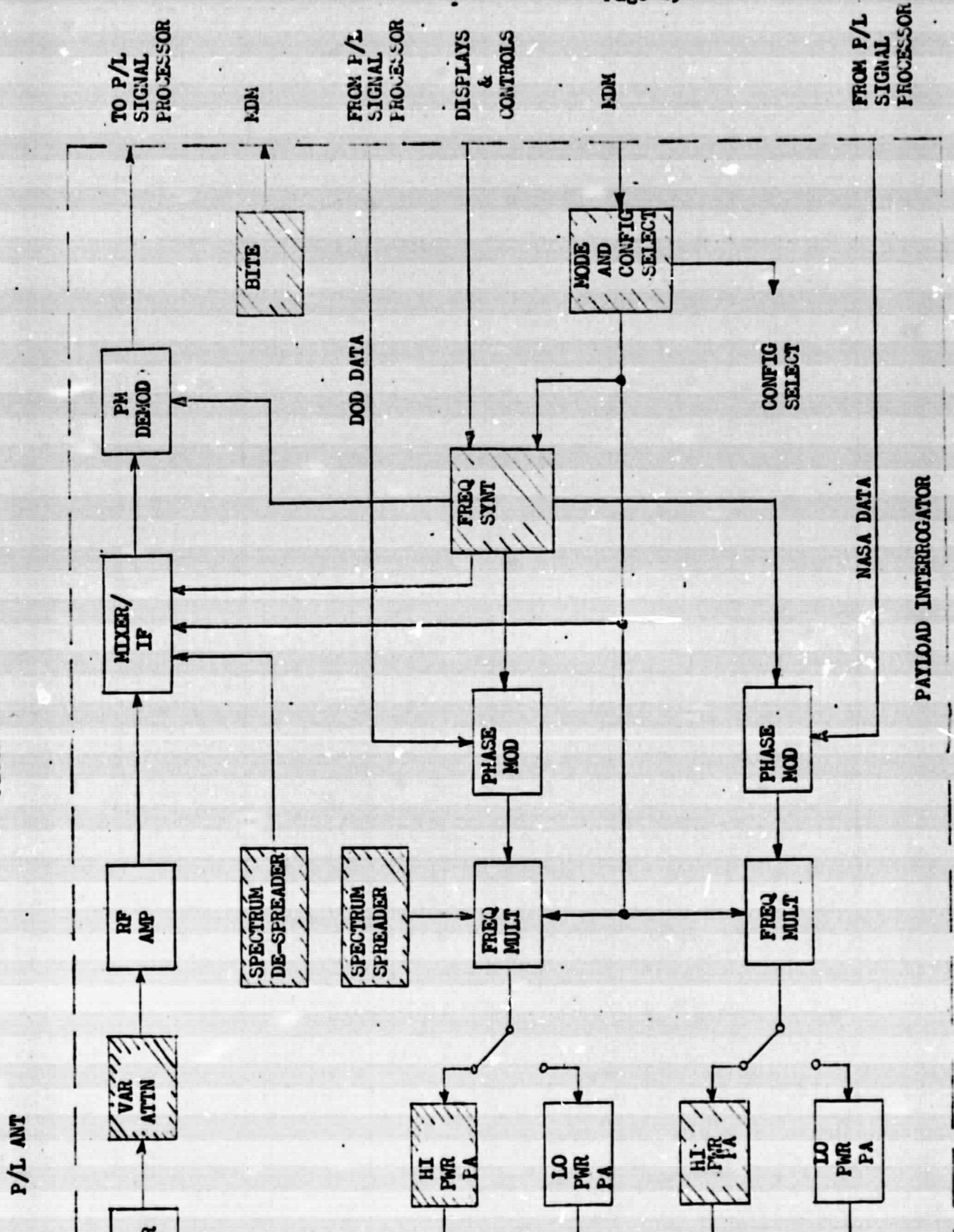
SHADED → NEW OR CHANGE FROM BASELINE

REF. RECP R00686A

PAYLOAD SIGNAL PROCESSOR

AWA 10/18/74

FIGURE 2



SHADED: NEW OR CHANGE FROM BASELINE
REF: RECP R00686A

REFERENCES

1. SPACE SHUTTLE PROGRAM REQUIREMENTS DOCUMENT; LEVEL I; MARCH 12, 1974; REV. NO. 6 (NASA OMSF)

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3. SUMMARIZED NASA PAYLOAD DESCRIPTIONS, SORTIE PAYLOADS, LEVEL A DATA-PRELIMINARY, JULY 1974 (MSFC)

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9. OCTOBER 1973 NASA MISSION MODEL ANALYSIS AND ECONOMIC ASSESSMENT, NASA TM X-64798, JANUARY 1974 (MSFC)

10. DSN STANDARD PRACTICE, DEEP SPACE NETWORK/FLIGHT PROJECT INTERFACE DESIGN HANDBOOK, JPL DOCUMENT 810-5 REV. C, 15 APRIL 1972

11. GODDARD SPACE FLIGHT CENTER, AEROSPACE DATA SYSTEMS STANDARDS, 1 JULY 1971

12. STS PLANETARY MISSION OPERATIONS CONCEPTS STUDY, MIDTERM REVIEW, 16 JULY 1974 (JPL)

13. IMPLEMENTATION STUDY, SHUTTLE SYSTEM/PAYLOAD SYSTEM COMMUNICATIONS DATA MANAGEMENT CHANGE REQUEST (PCIN S00686) (EJ5-74-311, EJ5-74-P54)

14. MINUTES, SPACE SHUTTLE PAYLOADS COORDINATION PANEL MEETING #2 (LP-8-297)

15. TDRS USERS' GUIDE (GSFC)

16. PAYLOAD INTERROGATOR SPECIFICATION MC478-0105, 8/25/74, ROCKWELL

17. PAYLOAD SIGNAL PROCESSOR SPECIFICATION MC476-0138, 7/19/74, ROCKWELL

CCBD NUMBERS	ECP NUMBERS	LYNDON B. JOHNSON SPACE CENTER ORBITER PROJECT OFFICE PROGRAM OFFICE CONFIGURATION CONTROL BOARD DIRECTIVE CHANGE PRIORITY	DATE 9-11-74
PCIN 00686	ECCP 00181		
JSC H00686C	RECP BC42-74/274 (8-2-74)	IMPACT ON ☒ ORB ☐ ME ☐ CFE ☐ SRB ☐ ET ☐ GSE ☐ PAYLOAD ☐ OTHER	PAGE 1 OF 6
MSFC		CHANGE TITLE	
KSC		Orbiter/Payload Interface Communications	

CHANGE IMPACT SUMMARY

GSE	☒
SPARES	☒
TRAINERS	☐
SOFTWARE	☒
FLIGHT PROGRAMS	☒
RTCC PROGRAMS	☐
STOWAGE	☐
SIMULATORS	☐
OTHER	☐

WEIGHT 109.1 (Delta Empty)
OTHER

ICDS AFFECTED
INTERCENTER
N/A

CONTRACT SPECIFICATIONS AFFECTED
N/A

NOMENCLATURE AND PART NO. OF AFFECTED END ITEM
Orbiter

EFFECTIVITY
OV 102 & Subs

		ESTIMATED COST	COST/FLIGHT
DDT&E	Inc #1- 5.4M		
PROD	#2- 8.6M		
TOTAL	14.0M		

SCHEDULE IMPACT

DISPOSITION AND DIRECTED ACTION:
CHANGE TO BE IMPLEMENTED ONLY WHEN ALL INTERFACE ACTIONS HAVE BEEN AUTHORIZED

BC4 Action: Issue CCA as follows:

The Shuttle Orbiter/payload interface shall be changed to provide the following capabilities:

(see page 2)

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cc:
BC4, WC2, EW, EJ, EJ5, EK, KSC/SP-MPC, TE, LP, WA4

AUTHORIZATION
APPROVED ☒
APPRD WITH MEVS ☐
DISAPPROVED ☐

CHANGE CATEGORY

MANDATORY		PRODUCT IMPROVEMENT	
MISSION REQUIREMENT	☐	COST SAVINGS	☐
COMPATIBILITY	☐	SCHEDULE IMPROVEMENT	☐
RECORD	☐	IMPROVE FIELD CHECKOUT	☐
DOCUMENTATION	☐	ENHANCE MISSION CAPABILITY	☐

ENDORSEMENTS
R. W. Kubicki — 9/13/74 DATE
D. A. Nebrig — 9-11-74 DATE
CF/M. P. — 9/11/74 DATE

SIGNATURE 9/27/74 DATE
CHAIRMAN CONFIGURATION CONTROL BOARD

for ... w/ J. L. Hanrigan, 9/16/74

CCBD (PCIN Number)	LYNDON B. JOHNSON SPACE CENTER	DATE 9-11-74
ORBITER	ORBITER PROJECT OFFICE	
OTHER	CONFIGURATION CONTROL BOARD DIRECTIVE CONTINUATION SHEET	PAGE 2 OF 6

1. Selectable Modulation/RF Configurations:

Ob

a. Provide additional modulation/RF frequency capabilities to accommodate each of the five classes of payloads defined below. Carrier and subcarrier frequencies, and modulation schemes, as defined below, will be selectable by both onboard and ground command. Adequate control and display parameters should be provided to allow system status display both onboard and via telemetry to the ground.

(1) Payloads Compatible with STDN:

Forward Link:

Modulation - PCM/PSK/PM (date on 30-kHz and/or 70-kHz subcarrier)

Carrier Frequency - 2025 to 2110 MHz in 115.1-kHz increments

Return Link:

Modulation - PCM/PM/PM (date on one of the following subcarriers: 48, 64, 128, 192, 256, 384, 576, 768, 1024, 1600 kHz.

Carrier Frequency - 2200 to 2290 MHz in 125-kHz increments

(2) Payloads Compatible with TDRSS Multiple Access:

Forward Link:

Modulation - PCM/PRN/PSK (spread spectrum modulation at baseband)

Carrier Frequency - 2092.59375 or 2106.40625 MHz*

Return Link:

Modulation - PCM/PRN/PSK (spread spectrum modulation at baseband)

Carrier Frequency - 2272.5 or 2287.5 MHz*

(3) Payloads Compatible with the Deep Space Network:

*Only one of these frequencies will be selected during the TDRSS design phase.

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Forward Link:

Modulation - PCM/PSK/PM (data on any existing DSN uplink subcarrier)

Carrier Frequency - 2110.243056 to 2119.792430 MHz in 341,049-Hz increments

Return Link:

Modulation - PCM/PSK/PM (data on any existing DSN downlink subcarrier)

Carrier Frequency - 2290.185185 to 2299.814815 MHz in 370,370-Hz increments

(4) Payloads Compatible with Air Force SGLS:

Forward Link:

Modulation - Carrier to be phase modulated by three ON-OFF keyed, amplitude-modulated tones (65, 76, and 95 kHz).

Carrier Frequency - 1763.721 to 1839.795 MHz in 4.004-MHz increments

Return Link:

Modulation - PCM/PSK/FM (data on 1.024-MHz subcarrier) and PCM/PSK/FM or (IRIG-FM/FM)/FM (data on 1.7-MHz subcarrier)

Carrier Frequency - 2202.5 to 2297.5 MHz in 5-MHz increments

(5) Payloads Compatible with Orbiter/TDRSS:

Forward Link:

Modulation - TDM/PSK (8-kbps command transfer rate (2 kbps information) or 8-kbps command transfer plus 32-kbps Δ-modulated voice)

Carrier Frequency - 2028.1354 to 2115.6145 MHz in 4.6041-MHz increments.

Return Link:

CCBD (PCIN Number)	LYNDON B. JOHNSON SPACE CENTER	DATE 9-11-74
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Modulation - TDM/PSK (16 kbps data or 16-kbps data plus 32-kbps Δ-modulated voice

Carrier Frequency - 2202.5 to 2297.5 MHz in 5-MHz increments

b. Signal processing (including channel encoding/decoding) and modulation/demodulation will be selectable by both onboard and ground command for each of the above payload types.

c. Acquisition capabilities will be provided for each of the above payload types.

d. RF power output and receiver dynamic range will be selectable by both onboard and ground command for each of the above payload types.

2. Selectable Command Bit Rates:

Provide the capability of commanding payloads at the following selectable bit rates (only the 8-kbps NASA command bit rate requires the capability to be time multiplexed with voice). The bit rates shall be selectable by both onboard and ground command. Status parameters shall be provided for onboard and ground personnel.

a. NASA Payloads:

(1) Detached - 1, 2, 4, 8, 16, 32, 64, 128, 256, 512, 1000, 2000, and 8000 (2-kbps information rate) bps.

(2) Attached - Same as detached, plus 3.84 Kbps.

b. DOD Payloads: 1, 2 K-band in either a secure or clear mode.

3. Command Hardline Interface:

Provide the following hardline outputs to attached payloads:

a. NASA Payloads: NRZ-L data line, Biϕ-L data line, clock line, payload enable line.

b. DOD Payloads: 1, 0, S data lines and clock line (clear and secure).

4. Selectable Telemetry Bit Rates:

a. Provide the capability of receiving telemetry data from payloads at the following selectable bit rates. The bit rates shall be selectable by both onboard and ground command. Status parameters shall be provided for onboard and ground personnel.

CCBD (PCIN Number)	LYNDON B. JOHNSON SPACE CENTER	DATE 9-11-74
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(1) NASA Payloads: 8 through 128 bps inclusive in 1-bps increments; and 1, 2, 4, 8, and 16 kbps.

(2) DOD Payloads: 250 bps, 500 bps, and 1, 2, 4, 8, 10, and 16 kbps (clear and secure).

5. Telemetry Hardline Interface:

Provide the capability to accept the following hardline inputs from attached payloads:

a. NASA Payloads: Single line Biø-L and NRZ-L plus clock.

b. DOD payloads: NRZ-L plus clock (clear or secure).

Delete the requirement for Orbiter to receive major and minor frame sync inputs.

6. Payload Direct RF Link -- Prelaunch:

Provide the capability for direct RF communication (transmit and receive) between payloads in the Orbiter payload bay (with payload bay doors open or closed) and the payloads GSE during the prelaunch mission phase. Design or protection shall be provided such that RF radiation inside the bay will not be detrimental to other systems, subsystems, or payloads. The link shall be S-band and shall interface with payload via the payload's antenna. The link shall not require an active Orbiter communication system.

Rockwell shall submit appropriate SCN's to Exhibit A and MJ070-0001-1A specification for NASA approval.

Include in Transmittal Letter

1. Within 30 days upon receipt of this CCA, the contractor shall prepare and submit a B&P proposal. The B&P shall include the following:

a. Schedule of implementation.

b. Provide cost and weight breakout by each of the six parts.

c. Provide separate cost and weight breakout for implementation of the ground configuration control for payload communication with telemetry of system status to the ground.

CCBD (PCIN Number)	LYNDON B. JOHNSON SPACE CENTER	DATE 9-11-74
ORBITER	ORBITER PROJECT OFFICE	
	CONFIGURATION CONTROL BOARD DIRECTIVE CONTINUATION SHEET	PAGE 6 OF 6
OTHER		

2. Reference is made to JSC letter BC42-74/274, dated 8-2-74, the request is hereby cancelled, paragraph 5, of CCA covers this request.

3. Reference letter 74MA204, SRR Payload Accommodation RID 11-A-1a, Payload Ground Communications. This CCBD will close letter 74MA204.

SPACE SHUTTLE
PROGRAM REQUIREMENTS DOCUMENT
LEVEL I

APPROVAL: M S Malkin
Director
Space Shuttle Program

Office of Manned Space Flight
Space Shuttle Program

1.0 INTRODUCTION

1.1 Purpose and Scope. The purpose of this document is to establish the Level I program requirements for the Space Shuttle Program. These are requirements established by the Director of the Space Shuttle Program as necessary to achieve the objective of the Space Shuttle Program, namely to: (a) reduce substantially the cost of space operations, and (b) provide a capability designed to support a wide range of scientific, defense, and commercial uses.

All Space Shuttle Program planning and direction of NASA Centers should be in accord with the requirements stated herein unless specific exception is approved in writing as an addendum to these Space Shuttle requirements by the Director of the Space Shuttle Program.

1.2 Changes. This document will be controlled in accordance with approved Space Shuttle Program Directive No. 1.

1.3 Related Documents. This document is in accord with the approved program approval document and program plan. Further detail pertaining to technical and operational requirements and to payload accommodations can be found in Level II documentation.

2.0 SPACE SHUTTLE SYSTEM REQUIREMENTS

2.1 Description. The Space Shuttle System flight hardware shall consist of a reusable Orbiter Vehicle including installed main engines, an expendable External Tank and reusable Solid Rocket Boosters which burn in parallel with the main engines. The Orbiter Vehicle shall be capable of crossrange maneuvering during entry, aerodynamic flight and horizontal landing.

2.2 Operating Life. As a design objective, the Orbiter Vehicle should be capable of use for a minimum of 10 years, and be capable of low cost refurbishment and maintenance for as many as 500 reuses.

2.3 Payload Bay Geometry. The payload bay shall be sized to have a clear volume of 15 ft. (4.5 meters) diameter by 60 ft. (18.2 meters) length. Payloads including their thermal and dynamic deflections shall be contained in an envelope equal to or less than 15 ft. (4.5 meters) in diameter and 60 ft. (18.2 meters) length. Payload attachment fittings and umbilicals shall extend beyond this envelope in order to mate with standard Orbiter fittings which are outside the payload envelope. A standard deployment mechanism and tie points shall be chargeable to the Orbiter Vehicle and shall not occupy the clear volume when stowed. Clearance for deployment and Orbiter deflections shall be provided by the Orbiter Vehicle. Available payload volume is reduced when the Orbiter Maneuvering System (OMS) incremental Delta V tankage or the docking module is carried.

2.4 Payload Mass Accommodation. The Space Shuttle System shall be capable of operating within the up payload range from zero to 65,000 lbs. (29,483 kg) for nominal launches and abort modes. Nominal down payloads shall be limited to 32,000 lbs. (14,515 kg). The Orbiter Vehicle payload C.G. limits for longitudinal, vertical and lateral axes are shown in figures 2-1, 2-2 and 2-3.

2.5 Crew/Passenger Accommodations. The cabin shall be designed to accommodate a total crew of seven, three crewmen to operate the Orbiter and up to four payload specialists. The Orbiter shall be provisioned for support of these personnel for 28 man days and up to 42 man days with no system change. All crew systems (such as seats and intercoms) for crew size greater than four and all consumables for duration greater than 28 man days shall be provided in kit form and shall be charged to payload. The design shall not preclude installation of crew support equipment for a total of 10 crew members as would be required to implement an Orbiter-to-Orbiter rescue.

2.6 Cabin Atmosphere. The Orbiter crew and passenger environment shall be a shirtsleeve, nominal 14.7 psi (760 mm Hg), two gas atmosphere (Nitrogen-Oxygen) to simulate sea level composition.

2.7 Extra Vehicular/Intra Vehicular (EVA/IVA) Provisions. The Orbiter shall provide an internal airlock for crew access to and from the unpressurized payload bay and pressurized modules, for EVA/IVA operations, and for space rescue. To support rescue, all Shuttle flights will carry EVA provisions for two trained crewmen and personal rescue systems for all other crew members.

2.8 Redundancy. The redundancy requirements for all flight vehicle subsystems (except primary structure, thermal protection system, and pressure vessels) shall be established on an individual subsystems basis, but shall not be less than fail-safe. "Fail-safe" is defined as the ability to sustain a failure and retain the capability to successfully terminate the mission. Redundant systems shall be designed so that their operational status can be verified during ground turnaround, and to the maximum extent possible while in flight.

2.9 Space Shuttle Main Engines (SSME). The Space Shuttle Main Engines will meet the requirements specified in the approved Space Shuttle Orbiter Vehicle/Main Engine ICD. Three engines will be used in the orbital flight configuration.

2.10 Reaction Control Subsystem (RCS). An Orbiter RCS shall provide three-axis angular control and three-axis translation including vernier capability. The RCS tankage shall be sized for TBD ft/sec.

2.11 Orbital Maneuver Subsystem (OMS). The OMS shall provide the propulsive thrust to perform final injection into orbit, circularization, orbit transfer rendezvous and deorbit. The OMS tankage shall be sized for a Delta V capability of 1,000 ft/sec (305 m/sec) based on Mission 1, as defined in paragraph 3.2a. Provisions shall be made to allow additional tankage to be incorporated in three Delta V increments of 500 ft/sec (152 m/sec), each for an overall total Delta V capability of 2,500 ft/sec (762 m/sec). The additional tankage and propellants will be located in the payload bay and the weights and volumes thereof charged to payload.

2.12 Airbreathing Engine Subsystem ABES). DELETED

2.13 Solid Rocket Boosters (SRB's). The SRB's will meet the requirements specified in the approved Space Shuttle Orbiter Vehicle/ET/SRB Interface Control Document. The two SRB's will operate in parallel with the main engines to provide impulse to the Orbiter Vehicle from lift-off to staging. The SRB's shall be designed for water recovery, refurbishment and subsequent reuse. As a design objective, the SRB case should be capable of 20 uses.

2.14 External Tank (ET). The expendable External Tank will carry all hydrogen and oxygen propellant for the main engines. The ET will conform to the requirements of the approved Space Shuttle Orbiter Vehicle/ET Interface Control Document.

2.15 Radiation and Avionics. - DELETED

2.16 Communications Subsystem. The Orbiter shall be capable of direct voice command, telemetry and video communication with the ground. The Orbiter shall be capable of TBD communication by relay through a communication satellite system. Provisions shall be made to accommodate equipment for secure voice and data communication.

2.17 Landing System. The Orbiter Vehicle shall have an automatic landing system.

2.18 Safety, Reliability, Maintainability and Quality. The provisions of NHB 5300.4 (1D), December 1972, "Safety, Reliability, Maintainability and Quality Provisions for the Space Shuttle Program" will apply for the Space Shuttle Program.

2.19 International Docking System. The Orbiter Vehicle shall meet the international requirements negotiated for compatible rendezvous, docking and crew transfer systems. The docking module will be provided as an optional kit in the payload bay and will be chargeable to payload.

3.0 OPERATIONAL REQUIREMENTS

3.1 General. The Space Shuttle System shall be designed to accomplish a wide variety of missions.

The Shuttle System weight carrying capability into circular orbit shall be based on the performance required to execute mission 3A. The equivalent maximum performance is shown in figures 3.1 and 3.2 for the range of inclinations and altitudes indicated. The payload capability curves assume a simple deployment mission with no rendezvous, 22 fps (6.9 m/sec) OMS Reserves, 4,500 lbs. (2,041 kg) of RCS propellant, and direct deorbit. (Reentry performance restrictions are addressed in Par 2.4. Detailed Shuttle System performance questions should be addressed to the JSC Shuttle Program Office).

Space Shuttle missions will involve direct delivery of payloads to specified low Earth orbits; placement of payloads and transfer stages in parking orbits for subsequent transfer to other orbits; rendezvous and station keeping with detached payloads for on-orbit checkout; return of payloads to Earth from a specified orbit; and provisions for routine and special support to space activities, such as sortie missions, rescue, repair, maintenance, servicing, assembly, disassembly and docking.

3.2 Reference Missions. The reference missions for the Space Shuttle System are described below and shall be used in conjunction with the other requirements specified herein to size the Space Shuttle System. For performance comparisons, Mission 1 will be launched from Kennedy Space Center (KSC) into a 60 by 100 n.mi. (111x185 km) insertion orbit and Mission 3 will be launched into the same insertion orbit from the Vandenberg AFB.

a. *Mission 1.* Mission 1 is a payload delivery mission to a 150 n.mi. (278 km) circular orbit. The mission will be launched due east and requires a payload capability of 65,000 lbs. (29,483 kg). The Boost phase shall provide insertion into an orbit with a minimum apogee of 100 n.mi. (185 km), as measured above the Earth's mean equatorial radius. The purpose of this mission is assumed to be placement of a 65,000 lb. (29,483 kg) satellite and/or retrieval of a 32,000 lb. (14,515 kg) satellite. The Orbiter Vehicle orbit translational Delta V requirements in excess of a 50 by 100 n.mi. (93x185 km) reference orbit are 650 ft/sec (198 m/sec) from the Orbital Maneuver Subsystem (OMS) and 100 ft/sec (30 m/sec) from the RCS.

b. *Mission 2.* DELETED

c. *Mission 3.* Mission 3 shall consist of two missions, one for payload delivery and one for payload retrieval.

d. *Mission 3(A).* This mission is a payload delivery mission to an orbit at 104 degrees inclination and return to the launch site in a single revolution. The boost phase shall provide insertion into an orbit with a minimum apogee of 100 n.mi. (185 km) as measured above the Earth's mean equatoral radius. The Orbiter Vehicle on-orbit translation Delta V requirements in excess of a 50 by 100 n.mi. (93x185 km) reference orbit are 250 fps (76 m/sec) from the Orbital Maneuver Subsystem (OMS) and 100 fps (30 m/sec) from the RCS. The ascent payload requirement is 32,000 lbs. (14,515 kg) and the return payload is 2,500 lbs. (1,134 kg).

e. *Mission 3(B).* This mission is a payload retrieval mission from a 100 n.mi. (185 km) circular orbit at 104 degrees inclination and return to the launch site in one revolution. The ascent payload weight is 2,500 lbs. (1,134 kg) and the return payload weight is 25,000 lbs. (11,340 kg). The Orbiter Vehicle on-orbit translation Delta V requirement in excess of a 100 n.mi. (185 km) circular orbit is 425 ft/sec (130 m/sec) from the OMS. The translational Delta V requirement from the RCS is 190 ft/sec (58 m/sec).

3.3 Launch Azimuth. The Space Shuttle System shall have a variable azimuth launch capability to satisfy the acceptable launch-to-insertion azimuths from both the KSC and Vandenberg AFB launch sites.

3.4 Crossrange. The Orbiter Vehicle shall have the aerodynamic crossrange capability to return to the launch site at the end of one revolution for all inclinations within the Space Shuttle System capability. Crossrange is to be achieved during entry, which is defined as beginning at 400,000 ft. (122 km) altitude and ending at 50,000 ft. (15 km) altitude.

3.5 Return Payload. The Orbiter Vehicle shall have the capability to land the design return payload of 32,000 lbs. (14,515 kg) with nominal wind and load factors and up to 65,000 lbs. (29,483 kg) return payloads under increased landing condition constraints.

3.6 Load Factors. The Space Shuttle System launch trajectory resultant load factors shall not exceed 3 G's for the Orbiter Vehicle. These limits do not apply to abort modes. The product of G forces and time shall not be detrimental to the crew/passengers.

3.7 Turnaround. When operational the Space Shuttle System flight hardware turnaround time from landing/return to the launch facility to launch readiness shall not exceed 160 working hours covering a span of 14 calendar days for any class mission.

3.8 Launch from Standby. The Space Shuttle System design shall provide the capability to be launched from a standby status within 2 hours, and hold in a standby status for 24 hours. Standby status is defined as ready for launch except main propellant fill, crew ingress and final systems verification.

3.9 Rescue. To fulfill the space rescue role, the Space Shuttle System shall have the capability to launch within 24 hours after the vehicle is mated and ready for transfer to the pad. If the spacecraft requiring aid has a docking system on that mission, the primary rescue mode will be by docking, with crew transfer through a pressurized tunnel. Otherwise, emergency rescue will be with pressure suits and personal rescue systems outside the spacecraft. The Orbiter Vehicle shall be capable of supporting the survival of a 4 - man crew for 96 hours after an in orbit contingency. Support for additional personnel shall be provided by the Orbiter and charged to the payload per paragraph 2.5.

3.10 Abort. The Space Shuttle System shall provide a safe mission termination capability through all mission phases. The performance capability to meet this requirement is defined as follows:

a. *Crew and Passenger Ingress Through Launch Commit Phase.* The emergency egress shall provide for crew and passenger evacuation to a safe area in a maximum time of two minutes (from crew ingress to swing arm retract).

b. *Launch Commit Through Return-to-Site Capability Phase.* The Shuttle System shall have a performance capability of intact (crew, payload and vehicle) abort and return to the launch site. The system design shall include adequate provisions for External Tank separation and disposal.

c. *Return-to-Site Through Orbit Insertion Phase.* The Orbiter shall have the capability (with one main engine out) to abort once around and return to the primary landing site from the point in the flight trajectory where a direct return-to-site capability ends.

d. *Orbital and Reentry Phase.* The abort mode after orbit insertion shall be early mission termination and return to a suitable landing site.

3.11 Loiter Time. - DELETED

3.12 Orbiter Transport. The Orbital Vehicle shall be capable of being transported by carrier aircraft.

3.13 Mission Duration. Mission duration of 7 days shall be used to size the Orbiter for self sustaining lifetime (from lift-off to landing) for a crew of four in accordance with Section 2.5. The Orbiter design shall not preclude the capability to extend the orbital stay time up to a total of 30 days by adding expendables.

3.14 Unmanned Flight. The Space Shuttle Systems design shall retain the option for unmanned vertical flight test operations.

3.15 Launch Rate. - DELETED. REFER TO THE CURRENTLY APPROVED PROGRAM DIRECTIVE ON CONTROLLED MILESTONES.

3.16 Operational Dates. - DELETED. REFER TO THE CURRENTLY APPROVED PROGRAM DIRECTIVE ON CONTROLLED MILESTONES.

3.17 Orbiter Vehicle Attitude-Constraints. For the purpose of thermal control and thermal protection system design, the following attitude constraints are defined:

For all missions with beta angles (Orbit plane relative to the solar vector) in the range from 0° to 60°, and for 3-axis inertial hold missions with beta angles in the range from 60° to 90°, the Orbiter shall be designed for a minimum 160 hours attitude hold with no attitude constraints and a maximum of 12 hours pre-entry conditioning.

For missions with beta angles in the range from 60° to 90° with worse case thermal orientation (other than 3-axis inertial holds), the Orbiter shall be designed for repeated cycles of a minimum 6 hours attitude hold with no attitude constraints, followed by a maximum of 3 hours thermal conditioning, and a maximum of 7 hours pre-entry conditioning.

4.0 ORBITER/PAYLOAD INTERFACE REQUIREMENTS

4.1 Payload Definition. Payloads referred to throughout this document are construed as the collective grouping of space hardware items such as: Spacelab, experiments, research equipment, satellites, support modules, adapters and fueled transfer stages or equipment, into appropriate composite flight packages. For definition of Shuttle/Orbiter payload accommodations, refer to Space Shuttle System Payload Accommodations Document. In the interest of maintaining minimum interface, (clean interface philosophy), payload designs should, where possible be self-sufficient systems, capable of checkout before installation in the Orbiter and adaptable to standardized interface concepts jointly developed between payloads and Space Shuttle.

4.2 Checkout. Payload performance testing and payload system checkout will be required prior to installation. Payload checkout while on the launch pad will be minimized and physical access to the payload will be limited. On-orbit status checks of the payload will be provided via the Orbiter prior to release and/or retrieval.

4.3 Data Management. The Orbiter shall provide standard displays and controls for monitoring the safety status of the payload. The payload shall provide to the Orbiter, at the interface, such information concerning the status or condition of the payload as is necessary to insure safe vehicle operation. Digital, discrete, and analog signals shall be conditioned by the payload and supplied to the Orbiter Vehicle. Such equipment and capability shall be chargeable to the payload. Payload unique control and display accommodation with the Orbiter cabin shall be chargeable to the payload. A minimum standard interface shall be provided to exchange data for safety and payload status checks, and vehicle and operational parameters, such as navigation, guidance and control. Additional support may be feasible during certain operational modes.

4.4 Payload Communication. The Orbiter shall provide direct and relay telemetry, command, and two-way voice capability with attached payloads and with released payloads. The Orbiter shall be capable of receiving and displaying limited payload data including video information and the RF downlink shall provide for relay of these limited payload data to the ground for both attached payloads and for released payloads.

4.5 Payload Safety. Payload elements shall have self-contained protective devices or provisions against payload generated hazards while the payload is attached to the Orbiter. Hazards generated by the Orbiter payload interactions during load, transport, deploy and recovery activities shall be identified and mutually resolved by the Shuttle and payload program offices.

4.6 Contamination. The Orbiter Vehicle shall be designed to minimize the generation, introduction and accumulation of contaminants within the cabin, payload bay, and around attached payloadmodules. Payload and Orbiter RCS thruster exhaust shall not impinge or be reflected on deployed payloads or into the open payload bay. The total level of contamination within the payload bay from all sources shall be controlled to minimize the effects on payloads during all phases of Shuttle operations.

4.7 Power. The Orbiter electrial power system shall provide for payload electrical energy allowance of not less than 50 kwh in the form of DC power to payloads through the Orbiter fuel cells. For missions with greater energy requirements, kits of approximately 840 kwh each will be provided outside the 15 ft. by 60 ft. (4.5x18.2 meters) clear payload volume and will be chargeable to payload. Power supplied by the Orbiter for payload on orbit consumption will be limited to 7 kw average and 12 peak. (Maximum duration peak power levels will be limited to 15 minutes duration at no less than 3 hour intervals.)

4.8 Attitude Control. Stability and attitude control requirements beyond those of the basic Orbiter Vehicle shall be provided by the payload system. The Orbiter Vehicle shall be capable of pointing at any ground, celestial, or orbital object within ±0.5 degrees. The Orbiter shall also be capable of accepting compatible commands from a payload supplied and payload-mounted sensor for positioning.

4.9 Rendezvous and Docking. The Orbiter Vehicle shall have an onboard capability to rendezvous and dock with an in-plane cooperative target or a passive stabilized orbiting element displaced up to 300 n.mi. (555 km). For Orbiter Vehicle preplanned docking missions, the docking mechanism will be installed in the payload bay. The weight of the docking mechanism and associated attachment fittings shall be chargeable to the payload.

4.10 Payload Attachment. The Orbiter shall provide standard discrete attachment points for mounting payloads. These attachment points shall be located along the payload bay, to accommodate different payload lengths and to allow for random order retrieval of multiple payloads.

4.11 Payload Deployment and Retrieval Mechanism. The Orbiter shall provide a payload deployment and retrieval mechanism which shall be stowed outside the 60 ft. (18.2 meters) length by 15 ft. (4.5 meters) diameter payload volume. This mechanism shall deploy the payload clear of the Orbiter mold line. Release of the payload from the deployment mechanism shall leave the payload and the Orbiter with only small residual rates. Spin-up capability, if required, will be accomplished by the payload.

For retrieval, the Deployment/Retrieval Mechanism shall interface with payloads designed for retrieval and, after attachment of the mechanism to the payload, shall align the payload in the payload bay to accommodate secure stowage of the payload. Additionally, the Payload Deployment and Retrieval Mechanism shall be capable of supporting the payload in the deployed position under the attitude stabilization and docking loads.

4.12 Payload Bay Vents. Provisions for venting the payload bay shall be provided by the Orbiter. This vent system shall minimize the impact of venting upon the attitude control system.

4.13 Payload Bay Access. The Orbiter and launch facility shall permit access to the payload bay for payload installation, service, and removal in the Orbiter flight preparation area and on the launch pad. Access for personnel and cargo to the paload bay shall also be available through the hatch, which interfaces the Orbiter crew compartment with the payload bay. Ground access to the payload bay will be limited to the period up to TBD hours before launch.

4.14 Propulsive Stages. The Orbiter design shall include provisions for fill, vent, drain and dump of liquid propellants of propulsive stages.

4.15 Acoustic Environment. The Orbiter Vehicle payload bay interior sound pressure level shall not exceed a maximum overall of TBD dB during liftoff sequence (T = 10 secs.) and TBD dB during other mission phases for the spectral frequency distribution shown in figure 4-1. (Figure 4-1 to be supplied at a later date).

FIGURE 2-1 LONGITUDINAL C.G. ENVELOPE

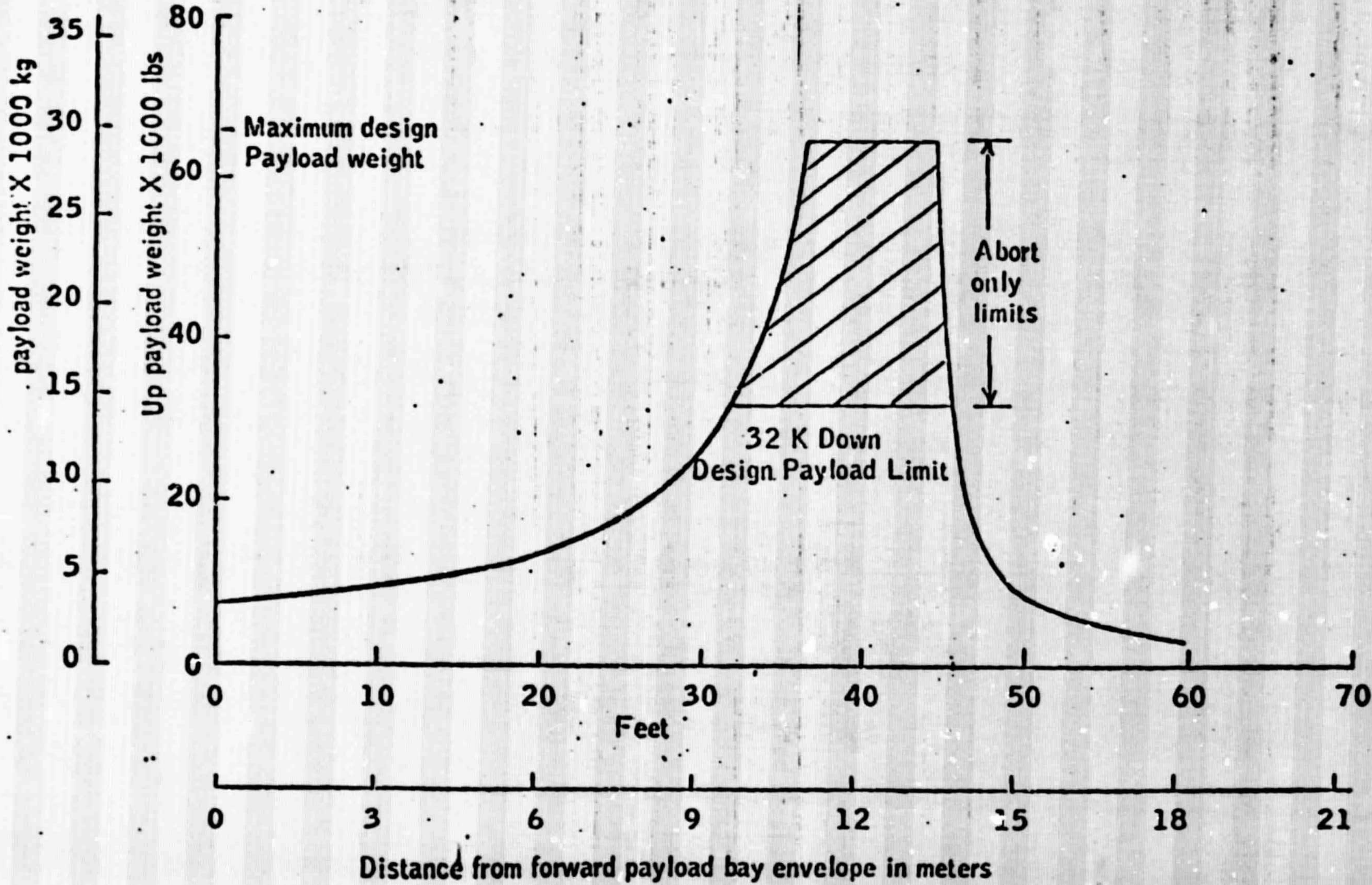


FIGURE 2-2 VERTICAL C.G. ENVELOPE

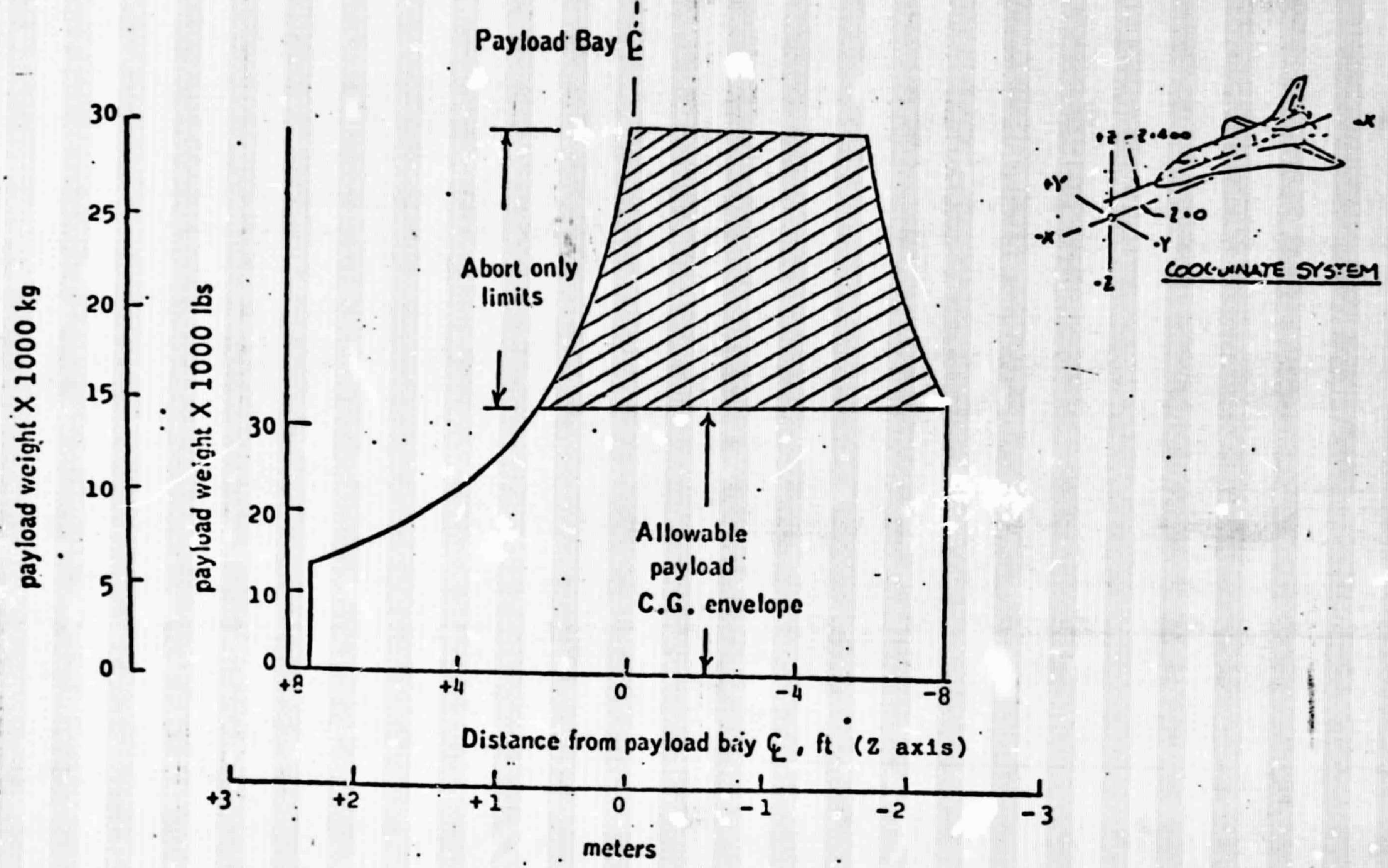
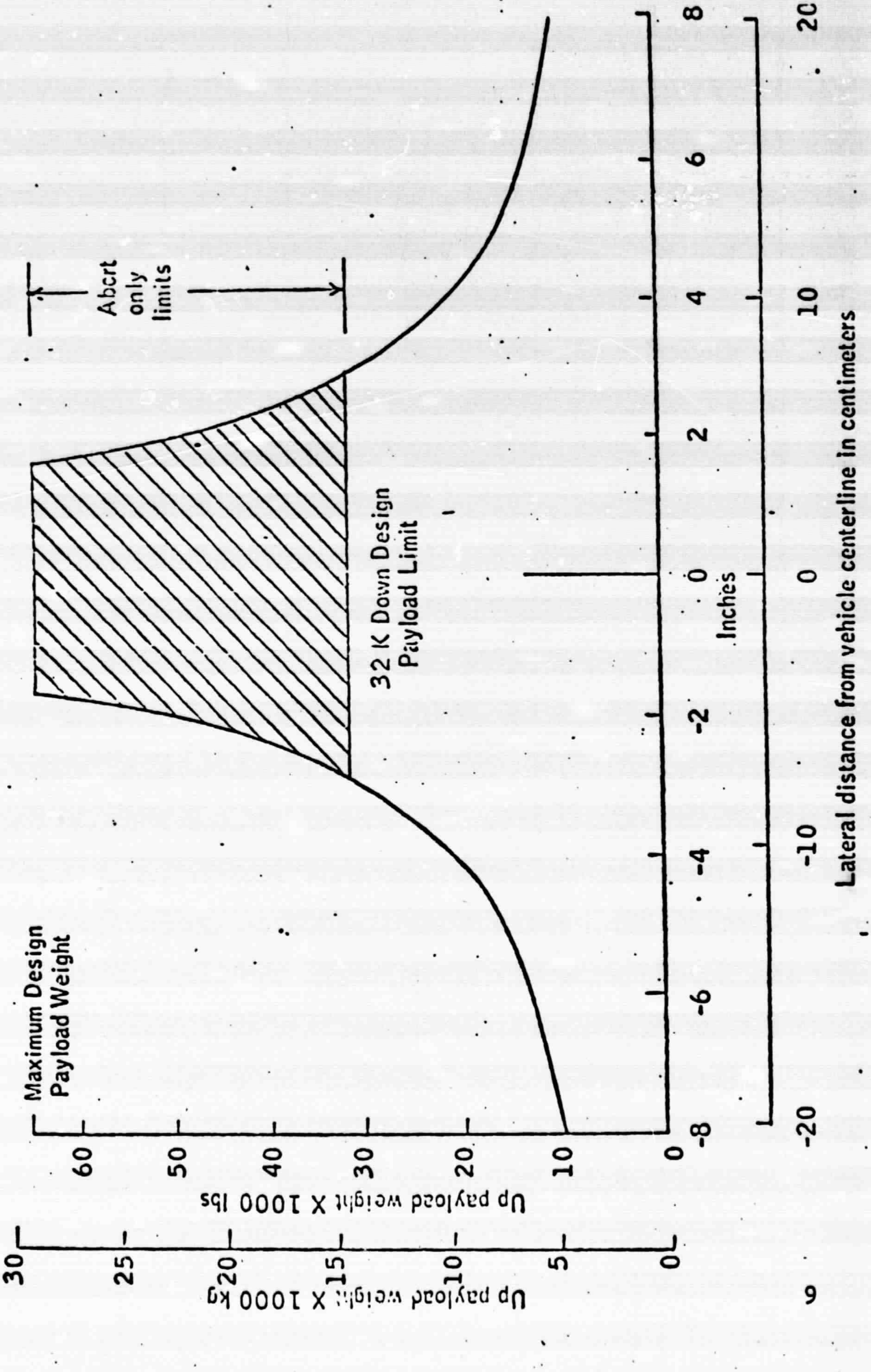


FIGURE 2-3 LATERAL C.G. ENVELOPE



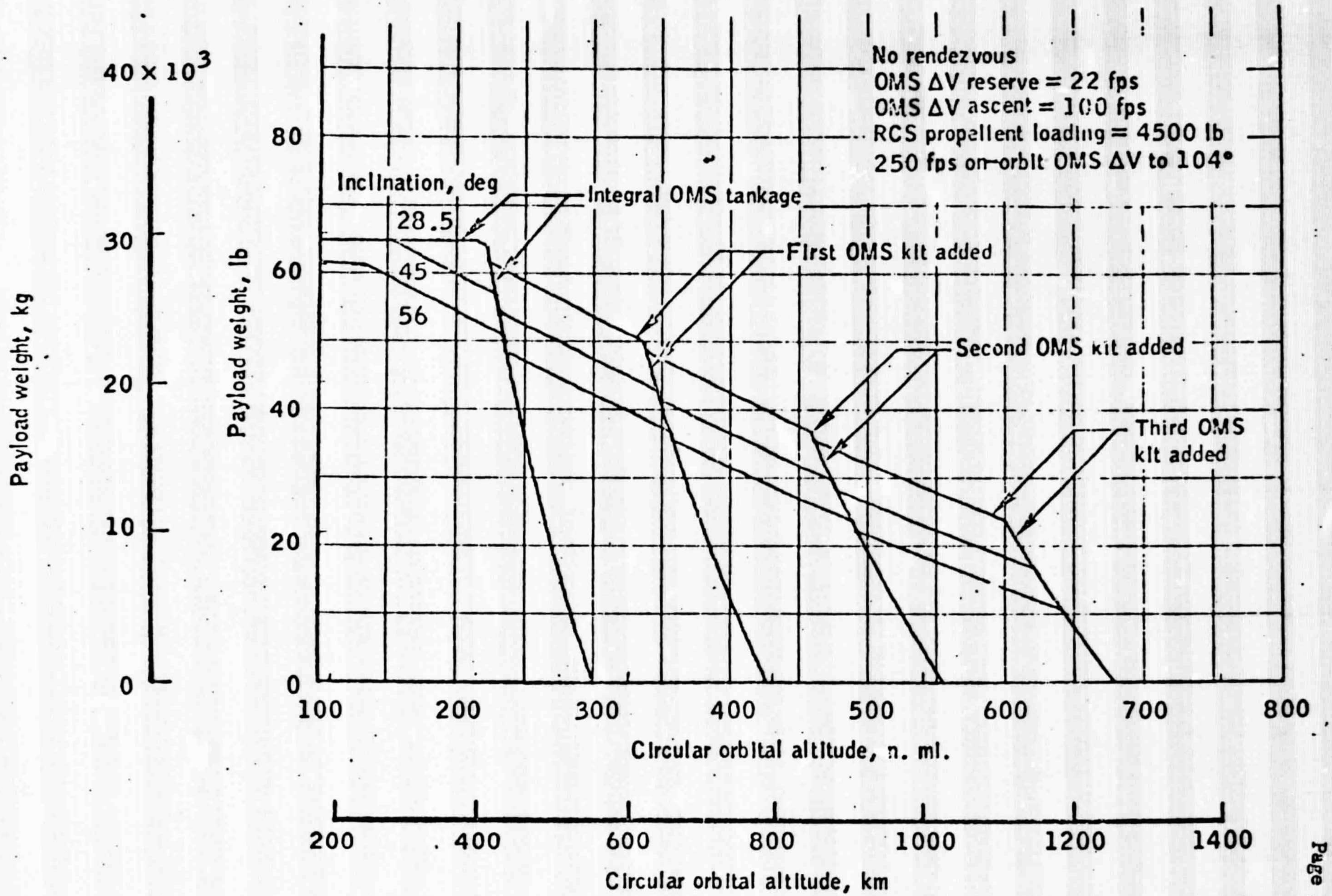


FIGURE 3-1 Shuttle payload with sub-orbital tank separation - Kennedy launch, delivery only.

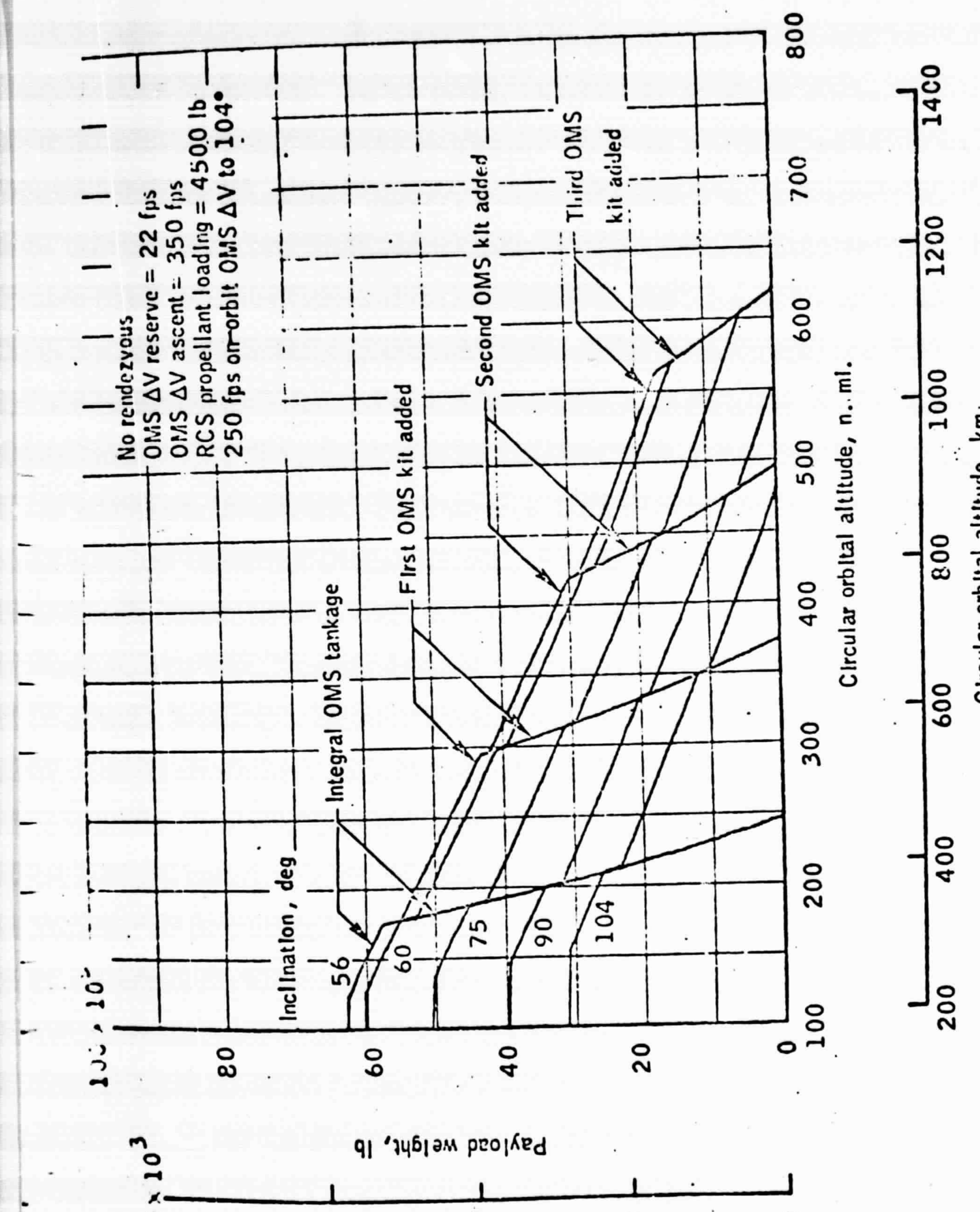


FIGURE 3-2 Shuttle payload with sub-orbital tank separation - WTR launch, delivery only.